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(54) **SECURE COMPUTING ENVIRONMENT**

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(57) **ABSTRACT**

A portable electronic device having a memory storing application software for initiating a payment transaction with a remote system, a data interface for coupling the device to a host computer, a contactless interface for receiving payment token data from a contactless payment token, and a cellular network interface for communication of data over a cellular network. The application software is executed from the device when the device is connected to the host computer and configures the portable electronic device to initiate a payment transaction by receiving payment token data via the contactless interface means and transmitting said payment token data to the remote system via the mobile network interface means.

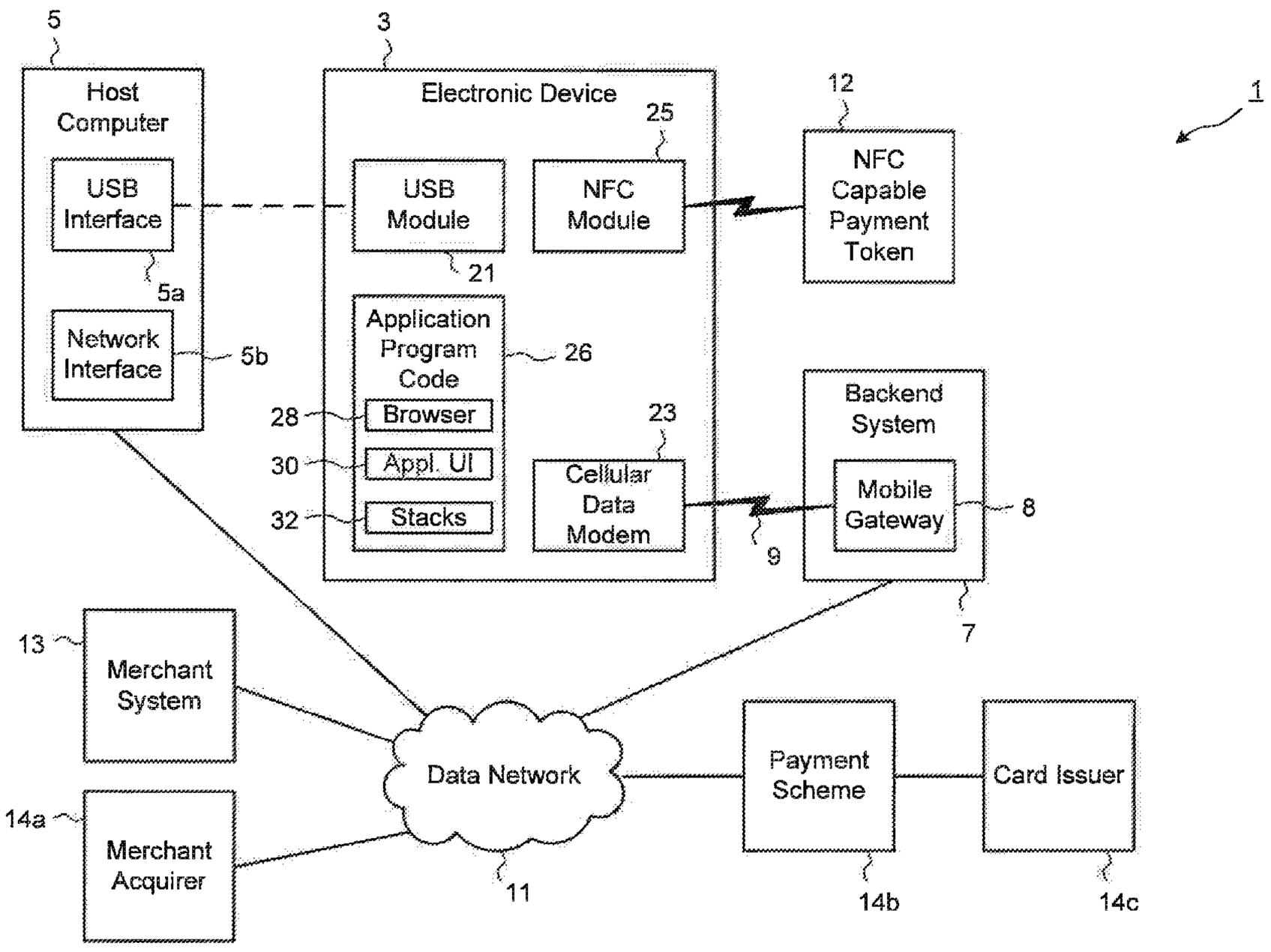


FIG. 1

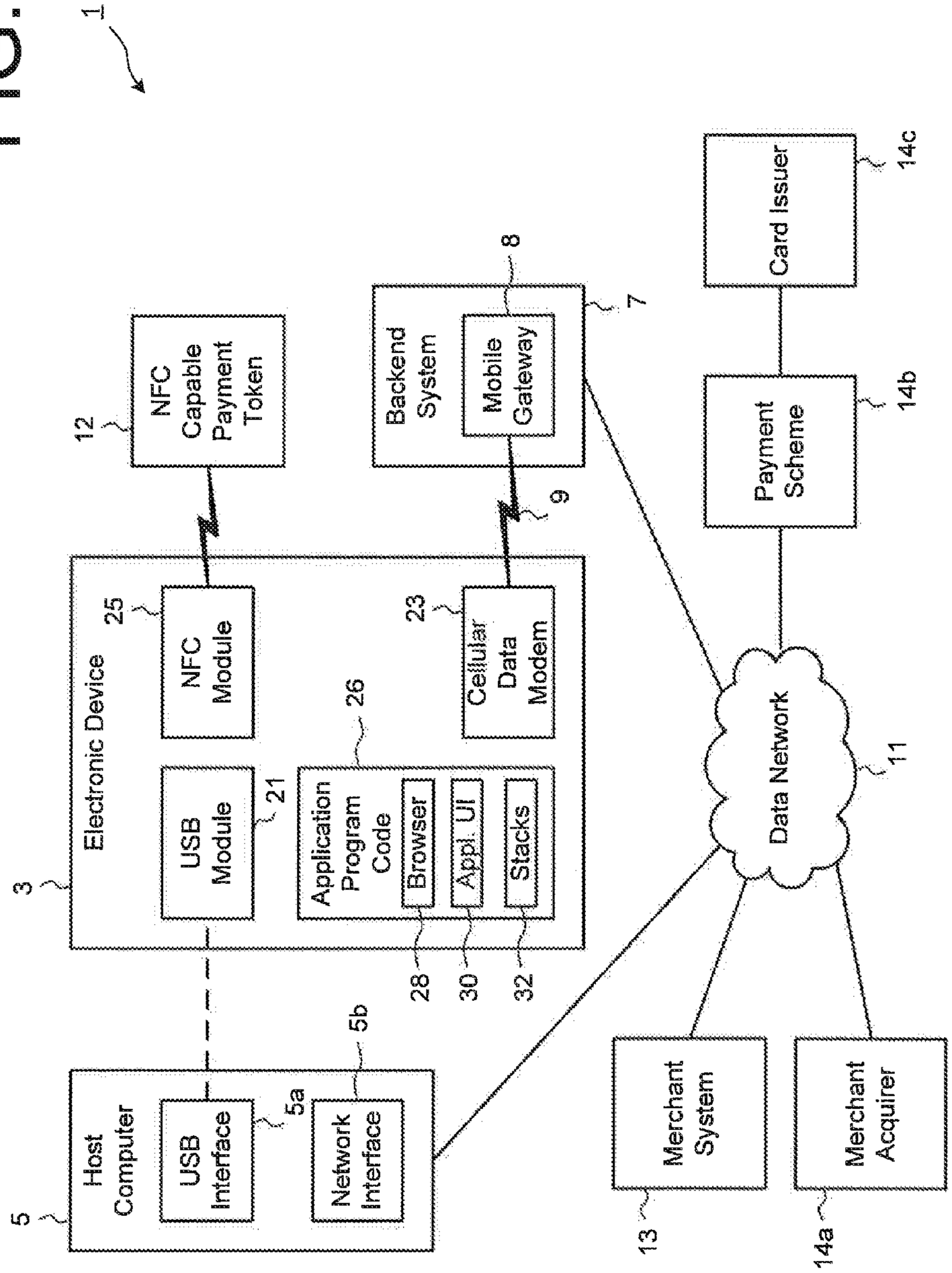
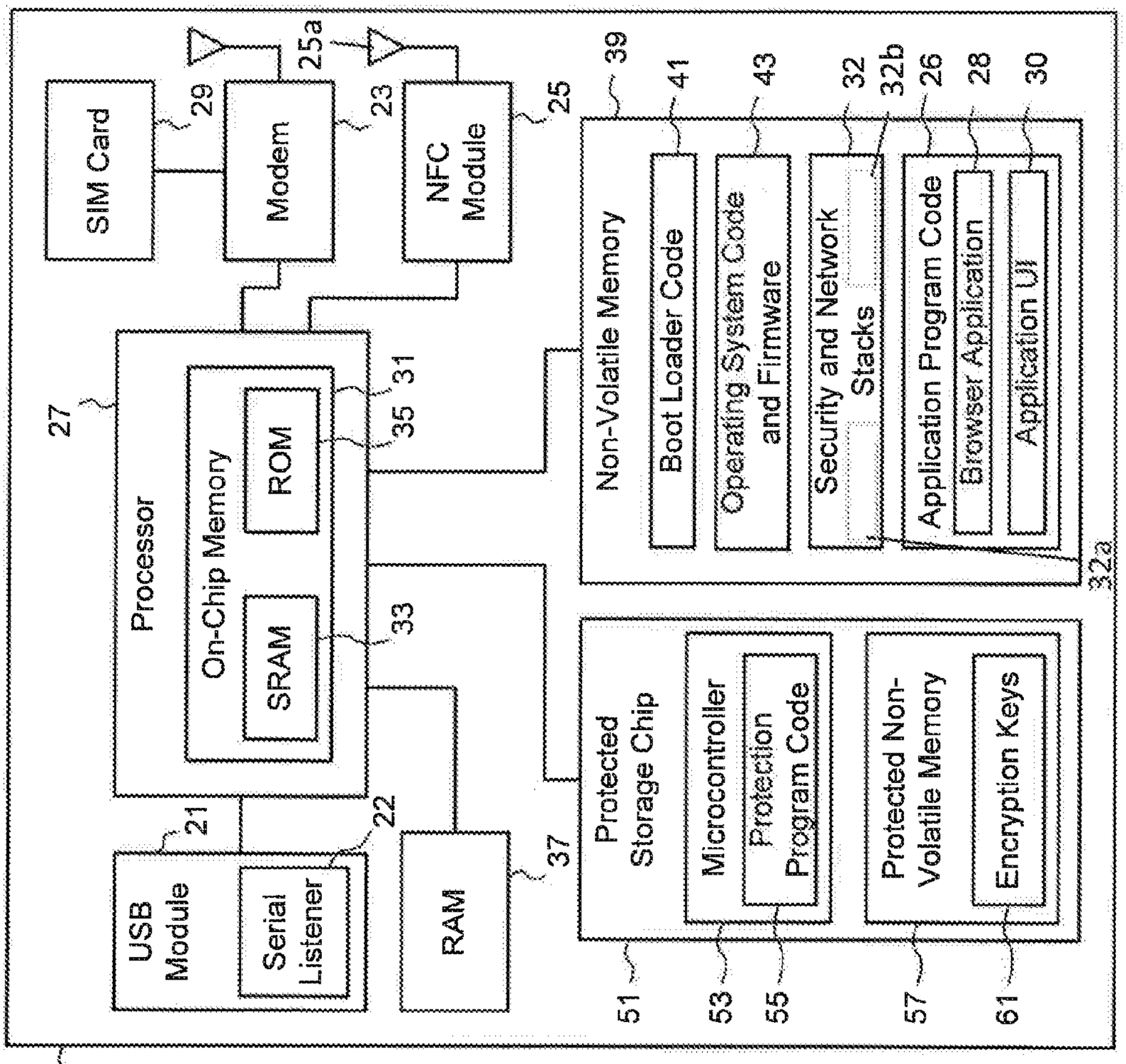

1
Electronic Device
3
USB Module
21
NFC Module
25
Application Program Code
26
Browser
28
Appl. UI
30
Stacks
32
Cellular Data Modem
23
NFC Capable Payment Token
12
Backend System
Mobile Gateway
8
7
9
Card Issuer
14c
Payment Scheme
14b
Data Network
11
Merchant System
13
Merchant Acquirer
14a
Host Computer
5
USB Interface
5a
Network Interface
5b

FIG. 2


3
27
Processor
On-Chip Memory
ROM
SRAM
31
35
33
SIM Card
29
Modem
25a
23
NFC Module
25
39
Non-Volatile Memory
Boot Loader Code
41
Operating System Code and Firmware
43
Security and Network Stacks
32
32b
Application Program Code
26
Browser Application
28
Application UI
30
32a
USB Module
21
Serial Listener
22
RAM
37
Protected Storage Chip
51
Microcontroller
53
Protection Program Code
55
Protected Non-Volatile Memory
57
Encryption Keys
61

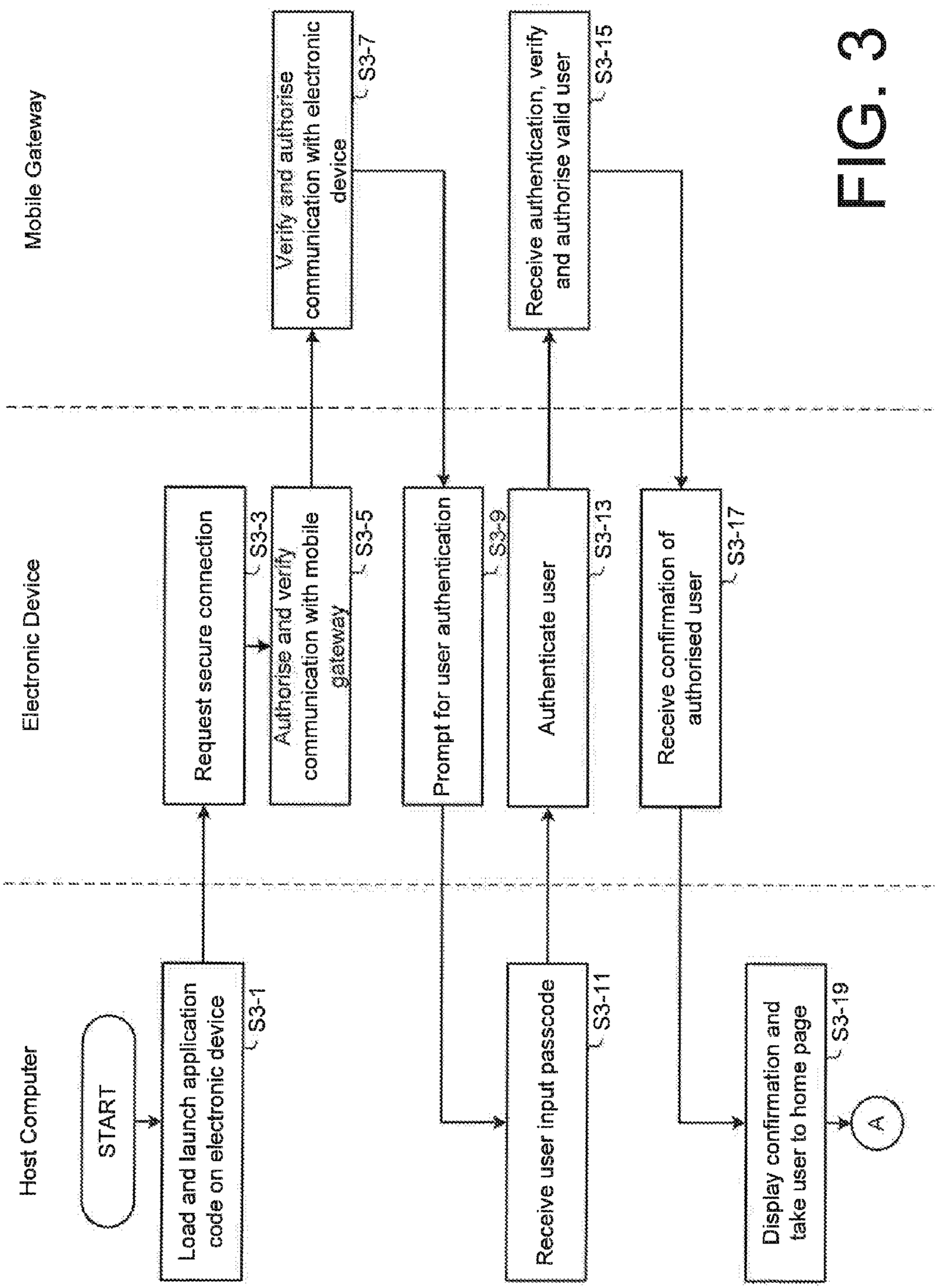

Mobile Gateway
Electronic Device
Host Computer
START
Load and launch application code on electronic device
S3-1
Request secure connection
S3-3
Authorise and verify communication with mobile gateway
S3-5
Verify and authorise communication with electronic device
S3-7
Prompt for user authentication
S3-9
Receive user input passcode
S3-11
Authenticate user
S3-13
Receive authentication, verify and authorise valid user
S3-15
Receive confirmation of authorised user
S3-17
Display confirmation and take user to home page
S3-19
A

FIG. 3

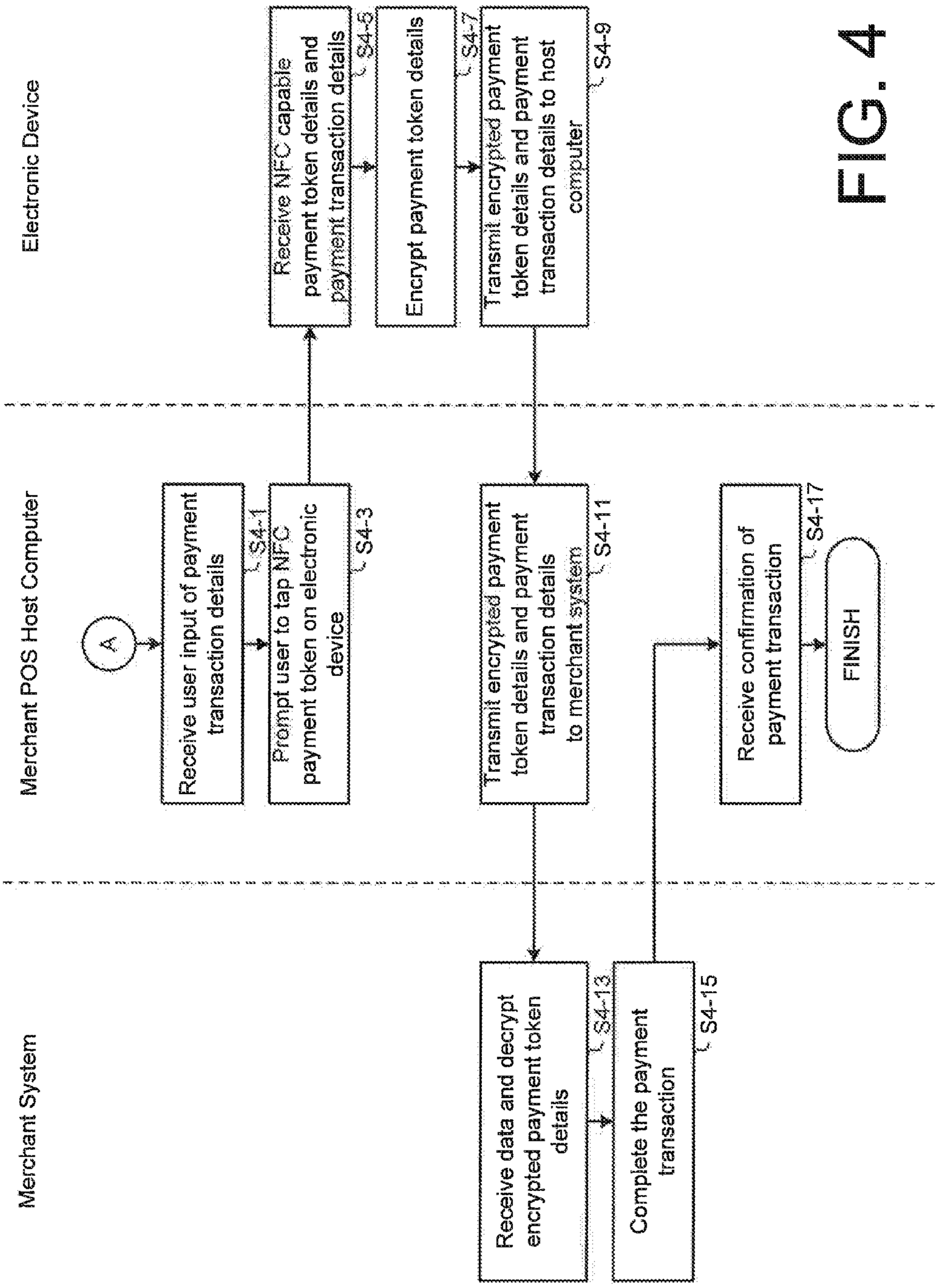

Electronic Device
Receive NFC capable payment token details and payment transaction details
S4-5
Encrypt payment token details
S4-7
Transmit encrypted payment token details and payment transaction details to host computer
S4-9
Merchant POS Host Computer
A
Receive user input of payment transaction details
S4-1
Prompt user to tap NFC payment token on electronic device
S4-3
Transmit encrypted payment token details and payment transaction details to merchant system
S4-11
Receive confirmation of payment transaction
S4-17
FINISH
Merchant System
Receive data and decrypt encrypted payment token details
S4-13
Complete the payment transaction
S4-15

FIG. 4

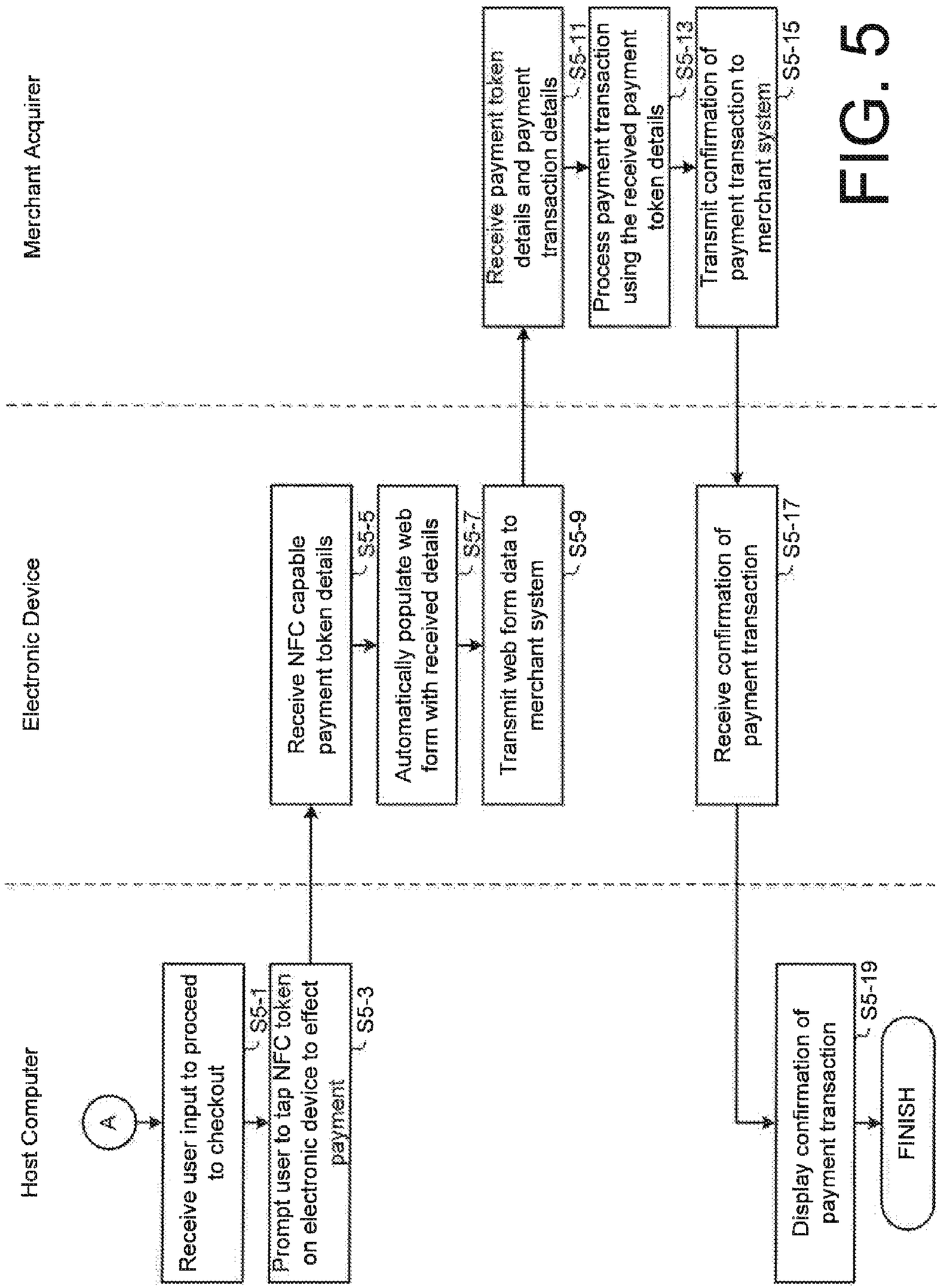

Merchant Acquirer
Electronic Device
Host Computer
A
Receive user input to proceed to checkout
S5-1
Prompt user to tap NFC token on electronic device to effect payment
S5-3
Receive NFC capable payment token details
S5-5
Automatically populate web form with received details
S5-7
Transmit web form data to merchant system
S5-9
Receive payment token details and payment transaction details
S5-11
Process payment transaction using the received payment token details
S5-13
Transmit confirmation of payment transaction to merchant system
S5-15
Receive confirmation of payment transaction
S5-17
Display confirmation of payment transaction
S5-19
FINISH

FIG. 5

SECURE COMPUTING ENVIRONMENT

FIELD OF THE INVENTION

[0001] This invention relates to secure data storage, access and communication, and more particularly to a system, device and method for providing access to online services in a secure computing environment.

BACKGROUND OF THE INVENTION

[0002] Secure computing environments that store and run software applications from a portable electronic Universal Serial Bus ("USB") flash memory device plugged into a host computer are generally known, such as IronKey, Imotion, Option CloudKey and Kobil mIDentity. Typically in such environments, secure authentication to the associated service and encryption is provided by the USB device itself. However, the USB flash memory devices in known environments rely at least in part on use of the host computer for processing and communication of data for a transaction. Therefore, known computing environments are susceptible to security breaches, for example, from malicious software or hardware resident on the host computer.

[0003] As such secure computing environments become more prevalent, there is a need for improved systems and techniques to provide enhanced protection and security of software application data and encryption key data that are stored in the protected memory of these devices.

STATEMENTS OF THE INVENTION

[0004] According to one aspect of the present invention, there is provided a portable electronic device comprising memory storing application software for initiating a payment transaction with a remote system. The portable electronic device also includes a data interface for coupling the device to a host computer and a contactless interface for receiving payment token data from a contactless payment token. A cellular network interface is provided for communication of data over a cellular network. In use, the application software is executed from the portable electronic device when the portable electronic device is connected to the host computer and configures the portable electronic device to initiate a payment transaction by receiving payment token data via the contactless interface and transmitting the payment token data to the remote system via the mobile network interface.

[0005] Preferably, the application software further configures the portable electronic device to establish a secure connection with a remote mobile gateway over the cellular data network. Preferably, the data interface comprises a Universal Serial Bus ("USB") data interface, the memory comprises a non-volatile flash memory, and the contactless payment token is a Near Field Communication ("NFC") capable payment card or mobile device.

[0006] Preferably, the application software comprises a web browser for displaying an application interface including a web form for initiating the payment transaction. The application software further configures the portable electronic device to automatically populate the web form with the received payment token data.

[0007] According to another aspect of the present invention, there is provided a method for secure transaction processing in a portable electronic device. The portable electronic device includes a memory storing application software executable from the device, a data interface for coupling the device to a host computer, a contactless interface for receiving payment token data from a contactless payment token, and a cellular network interface for communication of data over a cellular network. The method comprises executing the stored application software from the portable electronic device when the portable electronic device is connected to the host computer to initiate a payment transaction with a remote system. The method further includes receiving payment token data via the contactless interface, and transmitting the payment token data to the remote system via the mobile network interface.

[0008] In a further aspect of the present invention, there are provided associated computer programs arranged to configure a system or device to become configured as the above portable electronic device or to carry out the above method.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] There now follows, by way of example only, a detailed description of embodiments of the present invention, with references to the figures identified below.

[0010] FIG. **1** is a block diagram showing the main components of a secure computing environment;

[0011] FIG. **2** is a block diagram showing the main components of an electronic device in the secure computing environment of FIG. **1** according to an embodiment of the invention;

[0012] FIG. **3** is a flow diagram illustrating the main processing steps performed by components of the computing environment of FIG. **1** for an example of a device and user authorisation process;

[0013] FIG. **4** is a flow diagram illustrating the main processing steps performed by component of the computing environment of FIG. **1** according to a first embodiment; and

[0014] FIG. **5** is a flow diagram illustrating the main processing steps performed by component of the computing environment of FIG. **1** according to a second embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Secure Computing Environment

[0015] Portable USB flash memory devices that store and run software applications completely within the device itself are a way of providing highly secure control and access to online services in a secure computing environment, without using the network connection of the host computer to which the USB device is connected. In an online banking environment, the USB flash memory device provides secure access to a user's financial account data and account services provided by an online banking backend system, via custom browser software securely stored on the device that is automatically loaded and executed when the USB flash memory device is connected to a host computer, to render the custom browser user interface ("UI") for display to the user.

[0016] Referring to FIG. **1**, a secure computing environment **1** is made up of a number of components: the portable USB flash memory device (referred to herein as the "electronic device") **3**, the host computer **5** and the backend system **7**. The electronic device **3** is a secure and self-contained device with a USB serial communication module **21** for connecting the device to a USB interface **5***a* of the host computer **5**. The electronic device **3** also includes an on-board cellular data modem **23** for secure network access to services provided by a backend system **7**, via a direct and authenticated

connection to a mobile gateway **8** of the backend system **7** over a cellular data network **9**. The mobile gateway **8** may be a computer server providing APIs (Application Program Interfaces) to customer banking functionalities, such as looking up account balance, making payments, making transfers, etc.

[0017] The USB serial communication module **21** provides a link between custom browser software **28** and security and network stacks **32** on the electronic device **3**, in order to translate and transmit HTTP/HTTPS requests from the custom browser **28** running on the electronic device **3** via the host computer **5** over the USB serial communication module **21** and the serial USB interface **5***a*, and to return the responses back to the browser application **28**. Optionally, this USB serial communication module **21** can also include a set of interfaces that allow the custom browser **28** access to custom functions on the electronic device **1**

[0018] The cellular data network **9** may be any suitable cellular data communication network such as GPRS (General Packet Radio Service), EDGE (Enhanced Data-rates for Global Evolution), 3G (third generation of mobile phone mobile communications standards), LTE (Long Term Evolution), or 4G (fourth generation of mobile phone mobile communications standards), for example. The host computer **5**, which can be a personal computer, portable laptop, tablet PC, or the like, typically communicates data over a data network **11** via a communication network interface **5***b*. The host computer **5** may also include components included in commonly known computing devices, such as a processor, a display, user input devices and controllers, etc., which are not shown. The data network **11** may be any suitable data communication network such as a wireless network, a local- or wide-area network including a corporate intranet or the Internet, using for example the TCP/IP protocol. Such communication protocols are of a type that are known to those skilled in the art of data networks and need not be described further.

[0019] The USB device **3** also includes circuitry and logic to enable contactless payment transactions. In this embodiment, a Near Field Communication ("NFC") module **25** is provided to communicate data with an NFC capable payment token **12**, such as an NFC payment card or NFC capable mobile device with integrated payment software and/or hardware as are known in the art. Components of the host computer **5** can also be in communication with a merchant system **13**, which could be a merchant's Point of Sale (POS) backend system or an online merchant's website server system, as well as merchant acquirer **14***a*, payment scheme **14***b* and card issuer **14***c* components over the data network **11**, which are typically provided for authorizing and settling payment transactions with the merchant system **13**, and need not be described further.

[0020] In the normal user operation, the user plugs the electronic device **3** into the host computer **5** to automatically load and launch application program code **26** stored on the electronic device **3**. In an embodiment, the application program code **26** includes an application UI **30**, that can be built in HTML5 for example, and a custom browser application **28** that is used to render the application UI **30** to the user on the host computer **5**. Preferably, the browser application **28** is customized to restrict use for only the device application UI **30**. The browser application **28** is coupled to the USB serial communication module **21** to make HTTP requests and receive responses via the electronic device **3** rather than directly using the host computer's network interface **5***b*.

Electronic Device Architecture

[0021] Referring to FIG. **2**, an electronic device **3** according to an embodiment of the invention includes the USB serial communication module **21** and a modem **23**, as discussed above, that are coupled to a processor **27**. The electronic device **3** also includes a Subscriber Identity Module (SIM) **29** coupled to the modem **23**, and an NFC module **25** and associated antenna **25***a*. The processor **27** may be any type of processor, including but not limited to a general-purpose digital signal processor or a special purpose processor. Optionally, the processor **27** may include an on-chip memory **31**, for example, a Static Random Access Memory ("SRAM") **33** and a Read Only Memory ("ROM") **35**. The processor **27** is also coupled for access to a volatile Random Access Memory ("RAM") **37** and a non-volatile memory **39** of the electronic device **3**, for example via a data bus (not shown).

[0022] The non-volatile memory **39** stores boot loader code **41** executing a boot loader program upon loading, an operating system ("OS") code and firmware **43**, a code for the security and network stacks **32**, and a code for application programs **26**, including the custom browser application **28** and the application UI **30**. The processor **27** runs the boot loader code **41** upon power up of the electronic device **3**, to load the OS code **45**, the security and network stacks **32** and the application program code **26** into the RAM **37** for subsequent execution by the processor **27**. The security and network stacks **32** include a cryptographic library that provides encryption and decryption functionality for data communicated to and from the electronic device **3**.

[0023] The electronic device **3** is configured to route data traffic via the host computer **5**, or via the onboard cellular data modem **23**. The security stack **32***a* consists of all the components necessary to ensure secure access to the electronic device **3**, including device authorization, user authentication and network traffic encryption. The USB serial communication module **21** integrates with the security stack **32***a* to apply the necessary encryption and headers to the requests it receives from the browser application **28**. The network stack **32***b* consists of all the components necessary to make HTTP and HTTPS requests over the cellular data network **9** and the data network **11**. The USB serial communication module **21** also integrates with the network stack **32***b* to submit the requests it receives from the browser application **28**. Optionally, the electronic device **3** is configured with logic to perform routing of requests based on predetermined factors, such as signal strength, bandwidth speed, network data charges, etc. The electronic device **3** can determine connection availability and connection speed over the cellular data network **9** and if the cellular data signal is found to be weak or unavailable, the network stack may route the request via the network interface **5***b* of the host computer **5**.

[0024] Preferably, the non-volatile memory **39** consists of one or more flash memory components, although other forms of non-volatile memory may be suitable. Optionally, the non-volatile memory **39** can be divided into logical storage partitions, a main partition storing current firmware and application program code and a backup partition storing a working copy of backup firmware and application program code. One or more further spare partitions may be provided for future applications.

[0025] Optionally, the electronic device **3** can include a protected storage chip **51** coupled to the processor **27**, with a dedicated microcontroller (or microprocessor) **53** for executing a protection program code **55** that controls access to

encryption key data **61** stored in the protected non-volatile memory **57** on the storage chip **51**, as described in the Applicant's co-pending application entitled "Device and Method for Secure Memory Access". The protection program code **55** controls access to the protected non-volatile memory **57** by making the stored encryption key data **61** available only during a pre-defined time window, within a pre-defined number of clock cycles once the electronic device **3** is powered on. The loading of the encryption key data **61** can be carried out as one of the initial steps in a boot loading (or bootstrapping) process and prior to initiating and accepting any external communications to the electronic device **3**. The loaded encryption keys **61** are then available for subsequent use by the processor, when executing the OS code **43** and the application program code **45** to authenticate a user of the electronic device **3** and to handle service requests to and from the backend system **7**. Such key based encryption and decryption techniques are of a type that are known to those skilled in the art of data cryptography and need not be described further. Thereafter, the processor **27** in the boot loader mode executes the remaining instructions to continue normal loading of the boot OS code and initialisation of the external communication interfaces, such as the USB serial communication module **21** and the modem **23**.

[0026] Optionally, the electronic device **3** can be further adapted to include circuitry and logic to provide a defense against subversion of hardware attacks, such as voltage tampering, etc.

Device and User Authentication Process

[0027] An exemplary embodiment of the process of device and user authentication using the electronic device **3** will now be described with reference to FIG. **3**. At step S**3-1**, the user plugs the electronic device **3** into the host computer **5** to automatically load and launch the application program code **26** stored on the electronic device **3**. The custom browser application **28** is launched and used to render and display the application UI **30** to the user in the host computer **5** environment. The user can interact with the application UI **30** being displayed in the browser **28**, by clicking a link or a button to select one or more functions or services that requires communication with the mobile gateway **8** of the backend system **7**. In response, the browser application **28** sends a data request to a serial communication handler (not illustrated) on the host computer **5**, responsible for interfacing with the USB serial communication module **21** of the electronic device **3**. The serial communication handler sends the data requests to a serial listener **22** of the USB serial communication module **21**, via a USB serial driver installed on the host computer **5**.

[0028] At step S**3-3**, the processor **27** of the electronic device **3** requests a secure connection to the mobile gateway **8** of the backend system **7** over the cellular data network **9**, before user requests can be securely communicated with the backend system **7**. Accordingly, at step S**3-5**, authentication and authorization of the electronic device **3** is processed, by authorizing and verifying communication with the mobile gateway **8**. The requests are encrypted by the security stack **32***a* using the encryption keys **61** loaded into the SRAM **33** during the secure boot loading process described above.

[0029] The serial listener **22** of the USB serial communication module **21** sends the data request to the cryptography library of the security and network stacks **32**, to encrypt the data request using the encryption keys **61**. The serial listener **22** submits the request to the security and network stacks **32**, which first checks if good cellular signal strength is available via the cellular data modem **23**. If a strong cellular signal is detected, the data request is sent to the mobile gateway **8** over the cellular data network **9**. Otherwise, the request can be submitted using the host computer **5** network interface **5***b* over the data network **11**. It will be appreciated that this is one example of a possible data routing process by the electronic device **3**, and in other examples, the routing decision can instead or additionally be based on other predetermined cellular network-related factors, such as bandwidth speed, network data charges, etc. If the request is sent over the cellular data network **9**, the data request is converted into an encrypted HTTPS request using an Open SSL Library and passed to the cellular data modem **23**, which transmits the request to the mobile gateway **8**. On the other hand, if the request is sent using the host computer **5** network interface **5***b*, the serial listener **22** sends the request to the host computer **5** via the USB serial interface **5***a*. The HTTPS request is sent by the host computer **5** to the mobile gateway **8** over the data network **11** (e.g. the Internet) via the network interface **5***b*.

[0030] At step S**3-7**, the mobile gateway **8** authorizes and verifies communication with the electronic device **3**, in a corresponding manner. The electronic device **3** processes authentication of the user after the electronic device **3** has been authenticated. At step S**3-9**, the electronic device **3** prompts the user for authentication. User authentication can take one or more of any known forms, for example, by prompting the user to input a pre-registered passcode via the application UI **30** and browser application **28**, or via additional communication interfaces (not shown) that are made available on the electronic device, such as a thumbprint scanner, dials or buttons to select passcode digits, et. At step S**3-11**, the host computer **5** receives user input of a passcode via the application UI **30**. The user input passcode is verified by the electronic device **3** against a stored pre-registered passcode in order to authenticate the user at step S**3-13**. At step S**3-15**, authentication of the user is securely communicated to the mobile gateway **8**, which verifies that the user is valid by comparing received details with stored records for the user.

[0031] At step S**3-17**, the electronic device **3** receives confirmation from the mobile gateway **8** that the user is authorized. In response to confirmation that both the electronic device **3** and the user are authenticated and authorized, the browser application **28** and the application UI **30** display confirmation to the user and proceed with normal user operation at step S**3-19**, by displaying to the user a secure web home page for the services provided by a backend system **7**. In an alternative embodiment, the user can proceed to input an address of an online merchant system **13**, e.g. a Uniform Resource Locator ("URL"), for secure online shopping via the authenticated communication link between the electronic device **3** and the mobile gateway **8**, as will be described below with reference to FIG. **4**. In yet a further alternative embodiment, the user is a merchant at a POS, and the authenticated user can proceed to process a payment transaction using a customer's NFC capable payment token via the authenticated electronic device **3**, as will be described below with reference to FIG. **5**.

Merchant Point of Sale Embodiment

[0032] An embodiment of a process of secure contactless payment transactions using the electronic device **3** will now be described with reference to FIG. **4**, to illustrate the tech-

nical advantage of the secure computing environment described above. In this embodiment, the host computer **5** is a merchant POS host computer.

[0033] Referring to FIG. **4**, the contactless payment process continues from step S**3**-**19** above, where the application UI **30** of the browser application **28** on the host computer **5** prompts the user for payment transaction details. At step S**4**-**1**, the host computer **5** receives user input of the payment transaction details, such as the cost of an item or service to be purchased and/or an identifier of the item or service. The user input can be received via one or more conventional input devices, such as a keyboard, key pad, barcode scanner, etc. At step S**4**-**3**, the host computer **5** prompts the user to tap an NFC capable payment token **12** on the electronic device **3** to initiate the payment transaction. At step S**4**-**5**, the electronic device **3** receives payment token details from the NFC capable payment token **12** via the integrated NFC module **25** of the electronic device **3**.

[0034] At step S**4**-**7**, the electronic device **3** encrypts the received payment token details, using the encryption keys **61** loaded from the protected storage chip **51**. The electronic device **3** transmits the encrypted payment token details and the payment transaction details to the host computer **5** at step S**4**-**9**, over the USB connection via the USB serial communication module **21**. After receiving the data, the host computer **5** in turn transmits the encrypted payment token details and the payment transaction details to the merchant system **13** at step S**4**-**11**. In this embodiment, the host computer **5** communicates with the merchant system **13** over the data network **11** via a network interface **5***b*. Preferably, the host computer **5** establishes a secure connection over the data network **11**, such as an HTTPS connection, for an additional layer of data security. Alternatively, the electronic device **3** can be configured to transmit the encrypted payment token details and the payment transaction details to the merchant system **13** over the secured communication link to the mobile gateway **8** via the cellular data network **9**, and a subsequent link between the backend system **7** and the merchant system **13** via the data network **11**.

[0035] The merchant system **13** receives and decrypts the encrypted payment token details at step S**4**-**13**, before processing the payment transaction identified by the received payment transaction details, using the decrypted payment token details. It will be appreciated that shared symmetric keys or asymmetric keys **61** can be used by the merchant system **13** and the electronic device **3**, as are well known in the art. As an alternative, the merchant POS host computer **5** may include all of the merchant back-end system components to process the payment transaction via the merchant acquirer **14***a*, the payment scheme **14***b* and the card issuer **14***c*. In this alternative arrangement, the host computer **5** can instead communicate the encrypted payment token details and the payment transaction details to the merchant acquirer **14***a* to decrypt and process as described above. At step S**4**-**17**, the host computer **5** receives confirmation from the merchant system **13** via the data network **11** that the payment transaction is complete, and can display the confirmation to the merchant.

[0036] In this way, a secure connection between the portable electronic device **3** and the host computer **5** is established for the transmission of the encrypted payment token details to the merchant system **13** via the host computer **5**. Improved security is provided because the application program code **26** running directly on the portable electronic device **3** is effectively isolated from the host computer **5** and it is not possible for malicious software or the like on the host computer **5** to access or alter data stored and processed by the electronic device **3**, such as the payment token details used in the payment transaction. Moreover, both the user and the electronic device **3** are verified and authenticated via a secure connection to the mobile gateway **8** over the cellular data network **9**, again shielding the authentication process from potentially malicious software or hardware installed on the host computer **5**.

Online Payment Embodiment

[0037] An embodiment of a process of secure online payment transactions using the electronic device **3** will now be described with reference to FIG. **5**, to further illustrate the technical advantage of the secure computing environment described above. In this embodiment, the host computer **5** is a customer's host computer displaying the application UI **30** of the application program code **26** running on the portable electronic device **3** and the merchant system **13** includes a web server component (not shown) for hosting an online merchant website. It will be appreciated that the web server component could be provided as a separate component in communication with the merchant system **13** over the data network **11**.

[0038] Referring to FIG. **5**, the contactless payment process continues from step S**3**-**19** above, where the application UI **30** of the browser application **28** on the host computer **5** processes user input relating to an online request requiring a payment transaction to complete the request, to purchase or place an order for a product or service offered by the merchant via the online merchant website. At step S**5**-**1**, the host computer **5** receives user input indicating that the customer is ready to proceed with the payment transaction. The user can be prompted to press a checkout button displayed on an online shopping website, as is well known in the art. In response to receiving user input to proceed with the payment transaction, the host computer **5** displays a checkout web form and prompts for the user to tap an NFC capable payment token **12** on the electronic device **3** to initiate the payment transaction. Preferably, details associated with the online payment transaction, such as a merchant or purchase reference number and a transaction amount, are automatically read by the electronic device **3** and used to configure the checkout web form data. Optionally, the electronic device **3** can be configured to retrieve the payment token details from the NFC payment token **12** via the NFC module **25** prior to the payment transaction process, and to securely store the retrieved payment token details, in encrypted form in a non-volatile memory **39** or in the protected storage chip **51**. The stored payment token details can then be retrieved to populate the checkout web form without further user interaction.

[0039] At step S**5**-**5**, the electronic device **3** receives payment token details from the NFC capable payment token **12** via the integrated NFC module **25** of the electronic device **3**. In this exemplary embodiment, the electronic device **3** automatically populates the checkout web form with the received payment token details. Optionally, the electronic device **3** retrieves customer details associated with the received payment token details, such as a postal address for the registered customer, from the secure memory or a remote database, and automatically includes the retrieved customer details in the checkout web form data. At step S**5**-**9**, the checkout web form data is transmitted to the merchant acquirer **14***a* via the secure

and authenticated connection established between the electronic device **3** and the mobile gateway **8** over the cellular data network **9**.

[0040] At step S**5**-**11**, the merchant acquirer **14***a* receives the payment token details and payment transaction details, and processes the payment transaction identified by the received payment transaction details, using the received payment token details at step S**5**-**13**. Typically, the merchant acquirer **14***a* processes the payment transaction via the payment scheme **14***b* and the card issuer **14***c* to send the payment to the merchant's financial account. Once the merchant acquirer **14***a* confirms that payment for the transaction has been made, at step S**5**-**15** the merchant acquirer **14***a* transmits confirmation of the payment transaction to the merchant system **13**, and in turn it is received by the electronic device **3** at step S**5**-**17**. At step S**5**-**19**, the confirmation is displayed to the user by the host computer **5**, via the application UI **30** displayed by the browser **28** running on the electronic device **3**.

[0041] In this way, a secure connection between the portable electronic device **3** and the merchant acquirer **14***a* is established for the transmission of the data to process the online payment transaction via the authenticated mobile gateway **8**, whereby the merchant system **13** does not receive the customer's payment token details. Moreover, as with the embodiment described above, improved security is provided by isolating data communication and processing by application program code **26** running directly on the portable electronic device **3** from the host computer **5**, so that the host computer **5** is not able to access or alter the payment token details used in the payment transaction, nor are the payment token details transmitted over the potentially unsecured communication channel via the network interface **5***b* of the host computer **5**.

Alternative Embodiments

[0042] It will be understood that embodiments of the present invention are described herein by way of example only, and that various changes and modifications may be made without departing from the scope of the invention.

[0043] For example, in the embodiments described above, the portable electronic device is a USB flash memory storage device. It will be appreciated that the portable electronic device may be any device that is portable and used to store digital information. Additionally, the data communication interface between the portable device and a host computing device or platform may be any form of standard or proprietary computing interface, such as IEEE 1394 (Firewire), SCSI, Thunderbolt, Lightning, etc.

[0044] In the embodiments described above, the electronic device is powered by the host computer via the USB interfaces when connected. Optionally, the electronic device can include a battery and associated power charging circuitry, for powering the components of the device and enabling persistent storage of data in volatile memory if necessary.

[0045] In the embodiments described above, the cellular data network **9** and the data network **11** are illustrated as separate networks. It will be appreciated that the data network itself can include communication links or paths over a cellular communication network such as GPRS, EDGE, 3G, 4G, LTE, for example, or a combination of such communication paths.

[0046] The encryption keys and passcodes described above may take any respective form, and may be composed of numeric or alphabetic symbols, non-alphanumeric symbols, or a combination of such symbols.

[0047] Various software implementations are described in terms of the exemplary electronic device. After reading this description, it will become apparent to a person skilled in the art how to implement the invention using other computer systems and/or computer architectures.

[0048] The computer programs (also called computer control logic) discussed in the embodiments above, when executed, enable the computer system of the electronic device to implement embodiments of the present invention as discussed herein. Accordingly, such computer programs represent controllers of the computer system. Where the embodiment is implemented using software, the software may be stored in a computer program product and loaded into the computer system using a removable storage drive, a hard disk drive, or a communication interface. The terms "computer program medium" and "computer usable medium" are used generally to refer to media such as a removable storage drive, or a hard disk installed in hard disk drive. These computer program products are means for providing software to computer system of the electronic device. However, these terms may also include signals (such as electrical, optical or electromagnetic signals) that embody the computer program disclosed herein.

[0049] Alternative embodiments may be implemented as control logic in hardware, firmware, or software or any combination thereof.

What is claimed is:

1. A portable electronic device comprising:

a. a memory storing an application software for initiating a payment transaction with a remote system;

b. a data interface for coupling the portable electronic device to a host computer;

c. a contactless interface for receiving payment token data from a contactless payment token; and

d. a mobile network interface for communication of data over a cellular network;

wherein the application software is executed from the portable electronic device when the portable electronic device is connected to the host computer and configures the portable electronic device to initiate a payment transaction by receiving the payment token data via the contactless interface and transmitting the payment token data to the remote system via the mobile network interface.

2. The device of claim **1**, wherein the application software further configures the portable electronic device to establish a secure connection with a remote mobile gateway over the cellular network.

3. The device of claim **2**, wherein the secure connection with the remote mobile gateway over the cellular network is established by authorizing and verifying communication between the portable electronic device and the mobile gateway, and authenticating and validating a registered user of the portable electronic device.

4. The device of claim **1**, wherein the application software further configures the portable electronic device to encrypt the payment token data, and to transmit encrypted payment token data to the remote system.

5. The device of claim **4**, wherein the payment token data is encrypted using an encryption key stored in a protected non-volatile memory of the portable electronic device.

6. The device of claim **5**, wherein the application software is configured to transmit the encrypted payment token data to the remote system via the host computer instead of the mobile network interface.

7. The device of claim **1**, wherein the data interface comprises a Universal Serial Bus (USB) data interface.

8. The device of claim **1**, wherein the memory comprises a non-volatile flash memory.

9. The device of claim **1**, wherein the contactless payment token is a Near Field Communication (NFC) capable payment card or a mobile device.

10. The device of claim **1**, wherein the application software for initiating the payment transaction is operable to transmit data defining an application user interface for display by the host computer and to receive data defining user input via the application user interface from the host computer via the data interface.

11. The device of claim **10**, wherein: the application software comprises a web browser, the application user interface includes a web form for initiating the payment transaction, and the application software further configures the portable electronic device to automatically populate the web form with the received payment token data.

12. The device of claim **1**, further comprising a means for determining that data is to be communicated via the data interface based on cellular network connection availability or connection speed.

13. A computer-implemented method for secure transaction processing in a portable electronic device including a memory storing application software executable from the portable electronic device, a data interface for coupling the portable electronic device to a host computer, a contactless interface for receiving payment token data from a contactless payment token, and a mobile network interface for communication of data over a cellular network, the method comprising the steps of:

a. executing the stored application software from the portable electronic device when the portable electronic device is connected to the host computer to initiate a payment transaction with a remote system;

b. receiving the payment token data via the contactless interface; and

c. transmitting the payment token data to the remote system via the mobile network interface.

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